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A penicillium attack on hyacinth bulbs as affected by temperature and humidity

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Abstract

Penicillium corymbiferum is shown to be a parasite of hyacinth bulbs. The symptoms are described.

Cold storage at 9 °C was most favourable for development of the disease. Although the attack during storage was higher at 80% RH than at 50% RH, storage at 9 °C and 50% RH does not decrease the attack after planting.

Introduction

Penicillium is known as a parasite of several bulb crops. *P. corymbiferum* attacks tulip (Beyma Thoe Kingma, 1928), *Ornithogalum* (Phillips, 1960), iris (Saaltink, 1965), garlic (Smalley and Hansen, 1962) and probably also *Narcissus* (Plate and Schneider, 1967). *P. gladioli* (Cullock and Thorn, 1928) and *P. funiculosum* (Jackson, 1962) have been recorded on gladiolus. Lily is attacked by an unidentified *Penicillium* (O'Leary Keith and Guterman, 1937). A bulb decay caused by *Penicillium* was mentioned as important in the propagation of hyacinth bulbs (Bosher and Newton, 1948).

Since 1965 decay of hyacinths has become a problem in the Netherlands (Hoogeterp, 1967), following the development of a cold storage pre-forcing treatment at 9 °C. The decay was shown to be caused by *Penicillium corymbiferum*, which was isolated from diseased bulbs and identified by the Centraal Bureau voor Schimmelcultures, Baarn.

In view of the scanty information available on this disease a study has been made of the problem on hyacinths under both storage and greenhouse conditions.

Symptomatology

The disease was first noticed on bulbs in storage but it may also occur under glasshouse conditions. The symptoms are described below.

In storage. The first symptoms appear along the periphery of the basal plate. The infection then spreads in both lateral and vertical directions, the infected parts

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becoming pale brown. Occasionally the symptoms are localized to one side of the bulb. Within the tissues the mycelium is densest near the place of origin of the roots. At the sites of sporulation, which is especially profuse between the bulb scales, the colour changes to bluish green.

In the glasshouse. The symptoms of the disease under glasshouse conditions are almost the same as in storage, but the rate of spread of the disease is slower. The infection always starts from the point of emergence of the roots. Only in a few cases does the entire bulb become rotten, whereas in storage this is very common. Also sporulation between the bulb scales is less common under glasshouse conditions than in storage.

Materials and methods

The hyacinth cultivar 'Pink Pearl' was used throughout the investigations. In the experiments of Table 1 and 2, the bulbs used had a normal pre-forcing treatment of 6 weeks at 25 °C, followed by 4 weeks at 13 °C and 9 weeks at 9 °C. The other experiments were carried out with bulbs which had a treatment retarding normal development (30 °C until 15 October – $\frac{1}{2}$ °C until January and 25$\frac{1}{2}$ °C thereafter). These retarded bulbs could be used for planting after January.

The bulbs were inoculated by dipping the basal part for 30 sec. in a spore suspension containing approximately 2×10^6 spores/ml. Disease intensity was assessed visually, using the following scale of points.

Fig. 1. Hyacinth bulbs showing decay of the tissue visible from the outside, after removal of the dead bulb scales.

Fig. 1. De rotting van het weefsel is zichtbaar aan de buitenzijde na het verwijderen van de dode bolrokken.

Fig. 2. The bulb is often attacked as far as the centre, the decay starting at the base and developing upward through the tissue of the scales.

Fig. 2. De aantasting begint aan de bodem en ontwikkelt zich naar boven door het weefsel van de bolrokken, vaak tot in het centrum van de bol.

no symptoms	0	decay starts	50
initiation of symptoms	2	severe spread	70
clear symptoms	10	severe decay	85
fairly developed symptoms	25	whole bulb complete rotting	100

The "disease intensity" figure for each treatment, given in the tables, consists of the average figure obtained from assessments on all the bulbs in the treatment, using the above scale of points. In the experiments given in Table 3, 4 and 5 the bulbs were stored in growth chambers with adjustable temperature, humidity and light conditions.

Results

Behaviour of pathogen. The growth rate of the pathogen was measured by determining linear growth on PDA (Fig. 3) and also dry weight of mycelium. The optimal temperature for mycelial growth was found to be 20 °C. Sporulation was better at a slightly higher temperature. At 5 °C and 30 °C growth was very slow.

Disease development in storage and glasshouse affected by humidity. In preliminary experiments in a glasshouse, disease development was studied on inoculated bulbs planted in a vermiculite medium with various amounts of water. Moisture content was maintained by weighing the pots at regular intervals, adding water to keep the weight constant. Dry conditions were found to be favourable to the disease development, which may perhaps be attributed to the slow growth of roots under these conditions (Table 1). In a storage room at 9 °C, and at different degrees of relative humidity disease intensity was greatest at the high relative humidity (Table 2). A relative humi-

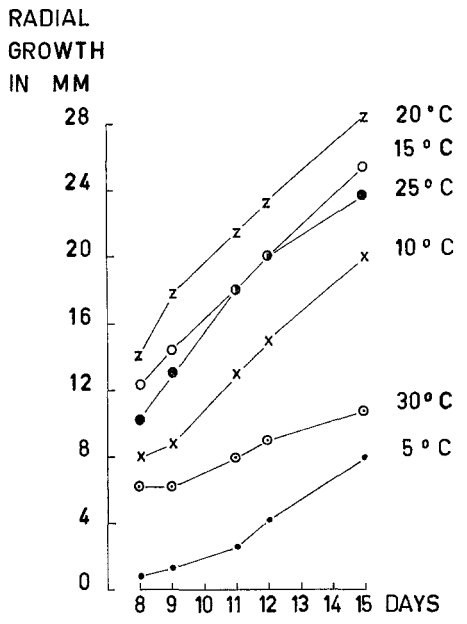

Fig. 3. Linear growth of hyphae on PDA plates at different temperatures.

Fig. 3. Lineaire groei van de hyphae op aardappel-glucoseagar bij verschillende temperaturen.

Table 1. Disease intensity on bulbs growing in vermiculite at 15 °C, as influenced by water content. (Mean value of 45 observations). Examined 6 weeks after inoculation.

Moisture content in vermiculite medium	Inoculated	Control
low	19.1 (±0.12)	0.0
medium	13.5 (±0.20)	0.0
high	5.7 (±0.12)	0.0

Tabel 1. De invloed van het vochtgehalte van vermiculite op de ziektegraad van bollen welke bij 15 °C in dit medium groeiden. (Gemiddelde van 45 waarnemingen). Zes weken na besmetting.

Table 2. Disease intensity after storage of bulbs at 9 °C, as influenced by humidity. (Mean value of 25 observations). Examined 4 weeks after inoculation.

Relative humidity	4 weeks after inculation	
	inoculated	control
50%	5.0 (±0.20)	0.0
75%	6.0 (±0.18)	0.0
>90%	17.0 (±0.88)	0.0

Tabel 2. Invloed van de relatieve luchtvochtigheid tijdens de bewaring bij 9 °C op de ziektegraad van bollen. (Gemiddelde van 25 waarnemingen). Vier weken na besmetting.

dity of 90% is close to that in commercial storage rooms maintained at 9 °C. It was observed that under humid conditions root tips were more active and the tissue was ruptured earlier.

Time of contamination and disease development. An experiment was done to determine whether there was any relationship between the time of inoculation and disease development under both storage and glasshouse conditions. Bulbs which were retarded until February were given the forcing treatment for 19 weeks (25 °C for 6 weeks, 13 °C for 4 weeks, and 9 °C for 9 weeks). Throughout this treatment relative humidity was maintained at 50 or 80%. Bulbs were inoculated at every change of temperature.

Table 3. Disease intensity during storage at 50 or 80% RH when bulbs were inoculated at the beginning of successive temperature treatments and classified at the end of each treatment (mean of 15 observations).

Treatment	Relative humidity	
	50%	80%
1. 25 °C 6 weeks after inoculation	4.0 (±0.10)	10.0 (±0.18)
2. 13 °C 4 weeks after inoculation	0.0 (±0.0)	4.0 (±0.82)
3. 9 °C 9 weeks after inoculation	26.0 (±1.23)	60.5 (±0.88)

Tabel 3. Ziektegraad gedurende bewaring bij 50 of 80% relatieve luchtvochtigheid waarbij de bollen werden besmet bij elke wijziging van temperatuur en beoordeeld aan het eind van iedere behandeling (gemiddelde van 15 waarnemingen).

Table 4. Disease intensity after completion of the whole forcing treatment, as influenced by relative humidity during storage and time of inoculation. (Mean of 15 observations).

Treatment	Relative humidity	
	50%	80%
1. Inoculated at the beginning of 25 °C treatment (in contact with pathogen for 19 weeks)	5.0 (+0.12)	0.0 (±0.0)
2. Inoculated at the beginning of 13 °C treatment (in contact with pathogen for 13 weeks)	24.0 (±0.24)	22.0 (±0.34)
3. Inoculated at the beginning of 9 °C treatment (in contact with pathogen for 9 weeks)	26.0 (±1.02)	57.0 (±1.18)
4. Inoculated when forcing treatment was over and kept for a few days before planting (in contact with pathogen for a few days)	0.0 (±0.0)	2.4 (±0.10)
5. Not inoculated at any stage of treatment	0.0 (±0.0)	2.0*(±0.0)

*Just a single bulb showed infection

Tabel 4. De ziektegraad na het voltooien van de gehele temperatuurbehandeling in afhankelijkheid van het tijdstip van besmetting en de relatieve luchtvochtigheid tijdens de bewaring. (Gemiddelde van 15 waarnemingen).

Table 5. Disease intensity after growing the treated bulbs in plastic pots with water, as influenced by relative humidity and time of contamination during the storage period. (Mean of 15 observations).

Treatment	Relative humidity during storage	
	50%	80%
1. Inoculated at the beginning of 25 °C treatment	7.5 (±0.01)	5.5 (±0.05)
2. Inoculated at the beginning of 13 °C treatment	16.5 (±0.13)	30.9 (±2.80)
3. Inoculated at the beginning of 9 °C treatment	49.5 (±2.90)	61.5 (±2.50)
4. Inoculated when entire forcing treatment was over and kept for a few days before planting	0.9 (±0.01)	4.0 (±0.02)
5. Not inoculated at any stage of forcing treatment	0.0 (±0.00)	0.0 (±0.00)

Tabel 5. De invloed van relatieve luchtvochtigheid en tijdstip van besmetting in de bewaarperiode op de ziektegraad, na de teelt van besmette bollen in plastic potten met water. (Gemiddelde van 15 waarnemingen)

Some bulbs of each treatment were examined when that particular treatment was over, while others were examined after the entire pre-forcing treatment had been completed. The observations recorded have been summarised in Table 3 and 4. The uninoculated controls remained healthy.

The results in Table 3 indicate that inoculation of the bulbs at the beginning of different treatments had different effects. At 25° and 13 °C, no or only moderate infections occurred. At 9 °C, however, the attack was severe, especially at high relative humidity.

The observations made at the end of the storage period, are given in Table 4. It is striking that early inoculation of bulbs did not lead to severe disease attack, even when bulbs were subsequently treated at 9 °C. Inoculation before the treatment at 13 °C, and still more before 9 °C, gave rise to more serious infections.

Fifteen bulbs of each treatment remaining at the end of the storage period were planted in water culture, one bulb per pot, and grown at 15 °C up to flowering. The results from these were somewhat different (Table 5). The attack under these conditions was almost equal for 80% RH and 50% RH at 9 °C, whereas immediately after storage the attack at 50% RH at 9 °C was considerably lower than that at 80% RH (Table 4).

Discussion

The data which have been presented confirm that *Penicillium corymbiferum* is a pathogen of hyacinth bulbs. It attacks bulbs in storage in the absence of artificial wounds.

Infection after planting is also possible (Table 1 and 5). In that case the rate of attack may be influenced by the speed of root development under dry or humid conditions (Table 1). This would accord with the results with iris, where slow root formation was found to favour the disease (Saaltink, 1968).

During storage a temperature of 9 °C was most favourable for attack by *Penicillium* whereas 25 °C was unfavourable. The disease intensity was highest at 80% RH. The

results indicate that at 50% RH and a temperature of 9° or 13°C spores germinate and a rather high percentage of the bulbs become diseased. However, as we did not prove that germination at 50% RH is possible, it has to be kept in mind that the spores were wet during the short period during which the bulbs were dipped in the suspension and were dried for 6 hours, in which period germination may have started. Storage at 9°C and 50% RH gives a rather severe attack after planting.

It may be predicted that disinfection of bulbs with fungicides will be most effective when applied just before the beginning of the treatment at 9°C.

If inoculated bulbs were stored first at 25°C (treatment 1 of Table 4), the subsequent attack at 9°C was very low. The spores had apparently lost the capability to infect. This is an interesting phenomenon which needs further study. Maybe it, also, is due to the very short period during which the spores were wet.

It seems that the host–pathogen relationship is affected by various factors, e.g.: the morphology of bulbs, physiologic changes in stored bulbs and the behaviour of the spores as influenced by different conditions.

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Samenvatting

De invloed van temperatuur en vochtigheid op een aantasting van hyacintebollen door Penicillium

Er is aangetoond dat *Penicillium corymbiferum* een parasiet van hyacintebollen is. De symptomen van deze ziekte worden beschreven.

Een bewaartemperatuur van 9°C geeft een sterkere aantasting dan bewaring bij 25°C of 13°C. Hoewel na een bewaring bij 80% RV de aantasting sterker is dan na bewaring bij 50% RV, is het verschil niet groot genoeg om praktische toepassingsmogelijkheden te doen verwachten. Vooral omdat de aantasting na het planten voor beide behandelingen gelijk is.

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